Zooplankton and water quality of lakes of the Northern Coast of Rio Grande do Sul State, Brazil.

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ABSTRACT: Zooplankton and water quality of lakes of the Northern Coast of Rio Grande do Sul State, Brazil. The indicator properties of zooplankton assemblages were evaluated along the environmental gradient of water quality caused by organic effluent discharge in the following lakes: Marcelino, Peixoto, Pinguela, Palmital, Malvas and Passo, located on the coastal plain of Rio Grande do Sul and connected by channels. The abundance of zooplankton species was interpreted by cluster analysis revealing a relationship to the limnological characteristics of the ecosystem. The data analyses of relative abundance were used to identify "sensitive", "indifferent", and "tolerant" species with the aim of selecting bioindicators of organic pollution. Brachionus caudatus, B. angularis, B. calyciflorus, Keratella cochlearis tecta, Euchlanis dilatata, Filinia longiseta, Bosmina longirostris, Moina micrura and Acanthocyclops vernalis were considered "tolerant" to organic pollution. K. cochlearis, K. americana, K. tropica, K. valga, Trichocerca capuccina, Pompholyx complanata, Ceriodaphnia cornuta cornuta, C. cornuta rigaudi, Diaphanosoma birgei and Notodiaptomus incompositus were considered "indifferent", while Bosminopsis deitersi, Moina minuta and Thermocyclops minutus were considered "sensitive" to organic pollution.
Key words: Zooplanktonic community, lakes, environmental variables, bioindicators, environmental quality.

RESUMO: Zooplâncton e a qualidade da água das lagoas costeiras do Rio Grande do Sul, Brasil. As propriedades indicadoras dos grupos zooplanctônicos foram avaliadas ao longo do gradiente de qualidade ambiental causado pela descarga de efluente orgânico nas seguintes lagoas: Marcelino, Peixoto, Pinguela, Palmital, Malvas e Lagoa do Passo, localizados na planície costeira do Rio Grande do Sul e que são interligadas entre si por meio de canais. As abundâncias das espécies, interpretadas através da análise de agrupamento, revelaram uma estreita relação com as características limnológicas do sistema. Os dados de abundância relativa, revelaram espécies "sensíveis", "indiferentes" e "tolerantes" à poluição orgânica. Brachionus caudatus, B. angularis, B. calyciflorus, Keratella cochlearis tecta, Euchlanis dilatata, Filinia longiseta, Bosmina longirostris, Moina micrura e Acanthocyclops vernalis foram consideradas tolerantes à poluição orgânica, K. cochlearis, K. americana, K. tropica, K. valga, Trichocerca capuccina e Pompholyx complanata, Ceriodaphnia cornuta cornuta, C. cornuta rigaudi, Diaphanosoma birgei e Notodiaptomus incompositus indiferentes e Bosminopsis deitersi, Moina minuta e Thermocyclops minutus , sensíveis à poluição orgânica.
Palavras-chave: comunidade zooplanctônica, lagoas, variáveis ambientais, bioindicadores, qualidade ambiental.

Introduction

Zooplankton species succession and spatial distribution result from differences in ecological tolerance to abiotic and biotic environmental factors (Marneffe et al., 1998).

According to Rocha et al., (1997), to understand such changes or to draw comparisons between natural systems and those that suffer disturbances, some knowledge of the struture of the community and of the main processes involved in nutrient cycling and production is required.

In the last few decades, considerable information regarding the effects of abiotic factors on zooplanktonic species has been acquired in both experimental and field research. The studies of Arora (1966); Radwan (1976) and (1980); Gannon & Stemberger (1978); Mäemets (1983); Blancher (1984); Berzins & Pejler (1989); Swadling et al. (2000), among many others, can be cited in this respect. However, despite their considerable potential as effective indicators of environmental change and their fundamental importance in the transfer of energy and nutrient cycling in aquatic ecosystems, the zooplanktonic communities have not been widely used as ecosystem condition indicators (Stemberger & Lazorchak, 1994).

In Brazil, this field is represent by the work of Carvalho (1983), Claro (1981), Matsumura-Tundisi & Okano (1983), Fallavena (1985), Matsumura-Tundisi et al. (1990), Domingos (1993), Sendacz (1993), Tundisi & Matsumura-Tundisi (1994), Talamoni & Okano (1997), Bozelli & Attayde (1998), Rocha et al. (1997) and Rocha et al. (2002), among others.

Considering the need for specific studies on some of the water resources of the coastal plain of Rio Grande do Sul, where the environmental quality of the water and the probable response of the aquatic biota are at stake due to changes imposed by constant human action, this investigation was based on the idea that the zooplankton could indicate, by its community composition and structure, the state of Lakes Marcelino, Peixoto, Pinguela, Palmital, Malvas, and do Passo. In that order, these lakes show a progressive environmental quality gradient, beginning with very low environmental quality at Marcelino Lake, that gradually improves along the sequence of lakes.

The hypothesis in the present study was that the zooplankton species would show, by analysis of quantitative sample data, the existence of this environmental gradient, as it would be possible to identify species as sensitive, indifferent, tolerant or benefited by environmental changes. The species with a constant frequency of occurrence in the system, showing high numerical abundance at the beginning of the gradient, would be classified as tolerant or benefited. Indiferent species were represented by negligible changes of numerical abundance along the gradient, and sensitive species were represented by high numerical densities at the least affected end of the gradient.

Material and methods

Study Area

The lakes of the coastal plains of Rio Grande do Sul, Brazil, are located between the 20° 12' and 33° 48'S parallels and 49° 40' and 53° 30'W meridians. Marcelino, Peixoto, Pinguela, Palmital, Malvas, and do Passo Lakes are part of Tramandaí System (Schwarzbold, 1982) that, in turn, is made up of two sub-systems: one to the north of the mouth of Tramandaí River, made up by the lakes Itapeva, dos Quadros, and the set of Osório Lakes; the other to the south, starting from Tramandaí Lake, passing through a necklace of lakes connected by channels until Porteira Lake. The second sub-system is connected through permanent natural channels to the northern sub-system that drains the water from the scarp slopes of the Serra Geral upland range. Marcelino Lake receives the sewage from the city of Osório and is connected by channels to the chain of lakes.

According to Pedrozo (2000), concerning the water quality, a gradient is observed from Marcelino, the first lake of the chain, to Passo Lake, the last one (Tab. I). This gradient is characterised, generally, by a decrease of nutrients and ion concentrations, conductivity, hardness, alkalinity, COD, BOD_5 and chlorophyll a and by a slight increase in dissolved oxygen and dissolved solids along the series of lakes. Total nitrogen, BOD_5, COD, total phosphorus and ammoniacal nitrogen showed very clearly changes due to the sewage input into the system, especially in the warmer months. Nitrite, nitrate, orthophosphate, chloride, chlorophyll a, magnesium, sodium, potassium, sulphide, alkalinity and conductivity, reflected the sequential and long-term effects of this contamination.

Table I: Data of physical and chemical variables according to Pedrozo (2000).(nd = not detected)

Variable	**Marcelino (min-max)**	**Peixoto (min-max)**	**Pinguela (min-max)**	**Palmital (min-max)**	**Malvas (min-max)**	**do Passo (min-max)**
Conductivity (mS cm^{-1})	(125.0-235.0)	(80.5-106.0)	(55.8-73.5)	(58.0-76.4)	(49.2-74.6)	(51.0-196.3)
Alkalinity (mEq.L^{-1})	(0.658-1.05)	(0.311-0.740)	(0.177-0.356)	(0.199-0.349)	(0.150-0.313)	(0.194-0.335)
Sulphates (mg.L^{-1})	(4.63-11.8)	(1.97-8.39)	(n.d-4.67)	(1.12-3.65)	(0.44-5.17)	(0.61-3.32)
Chloride (mg.L^{-1})	(20.7-38.1)	(16.2-32.5)	(10.6-17.6)	(12.5-19.5)	(10.1-16.7)	(11.0-44.1)
COD (mg.L^{-1} O_2)	(30.5-47.1)	(11.3-35.7)	(8.5-32.4)	(9.7-33.3)	(3.2-29.7)	(12.5-28.8)
BOD_5 (mg.L^{-1} O_2)	(3.35-11.55)	(1.36-4.44)	(0.40-2.93)	(0.5-2.70)	(0.23-3.10)	(0.40-2.10)
Total Nitrogen (mg.L^{-1})	(1.74-5.33)	(0.79-2.35)	(0.54-2.22)	(0.47-2.35)	(0.55-2.19)	(0.150-2.50)
Amoniacal Nitrogen (mg.L^{-1})	(515.0-844.0)	(36.6-182.0)	(36.6-196.0)	(70.2-210.0)	(33.6-186.0)	(51.8-160.0)
Total phosphorus (mg.L^{-1})	(266.0-573.0)	(38.6-183.0)	(24.8-207.0)	(66.2-193.0)	(11.0-187.0)	(21.4-152.0)
Chlorophyll a (mg.L^{-1})	(0.75-44.1)	(1.69-10.1)	(nd-7.35)	(0.37-4.52)	(nd-8.47)	(0.75-8.47)

According to Fonseca (1989), no methodical social-economic surveys have been carried out to the north of the Tramandaí. Farming (rice cultivation and cattle raising) is the main source of income in the region; there are no industrial centres, and tourism only occurs during the summer months.

Figure 1 shows the location of the sampling sites in the lakes of the northern coast of Rio Grande do Sul. The number of stations in each lake was established taking into account the surface area in km² of each body of water and the direction of the wind, which is from the northeast, was also fundamental in the choice of locations.

Two stations were established at Marcelino Lake (M1 and M2), 3 in Peixoto Lake (PE3, PE4, PE5), 5 in Pinguela (PI6, PI7, PI8, PI9, PI10), 3 in Palmital (PA11, PA12, PA13), 3 in Malvas (MA14, MA15, MA16), and 3 sampling stations in the do Passo Lake (PAS17, PAS18, PAS19). Full details of the physical and chemical variables measured are given in Pedrozo (2000).

Sampling Methodology

Samples of zooplankton were collected in January, May, July and October of 1997 from the entire water column; 300 liters of water were filtered using a suction pump and plankton nets of 65 mm mesh and fixed in 4% formaldehyde.

Identification keys, diagnosis, and descriptions based on: Goulden (1968), Ruttner-Kolisko (1974), Koste (1978), Sendacz & Kubo (1982), Reid (1985), Montu & Goeden (1986), Elmoor-Loureiro (1997) were used for the taxonomic identification of the zooplankton species.

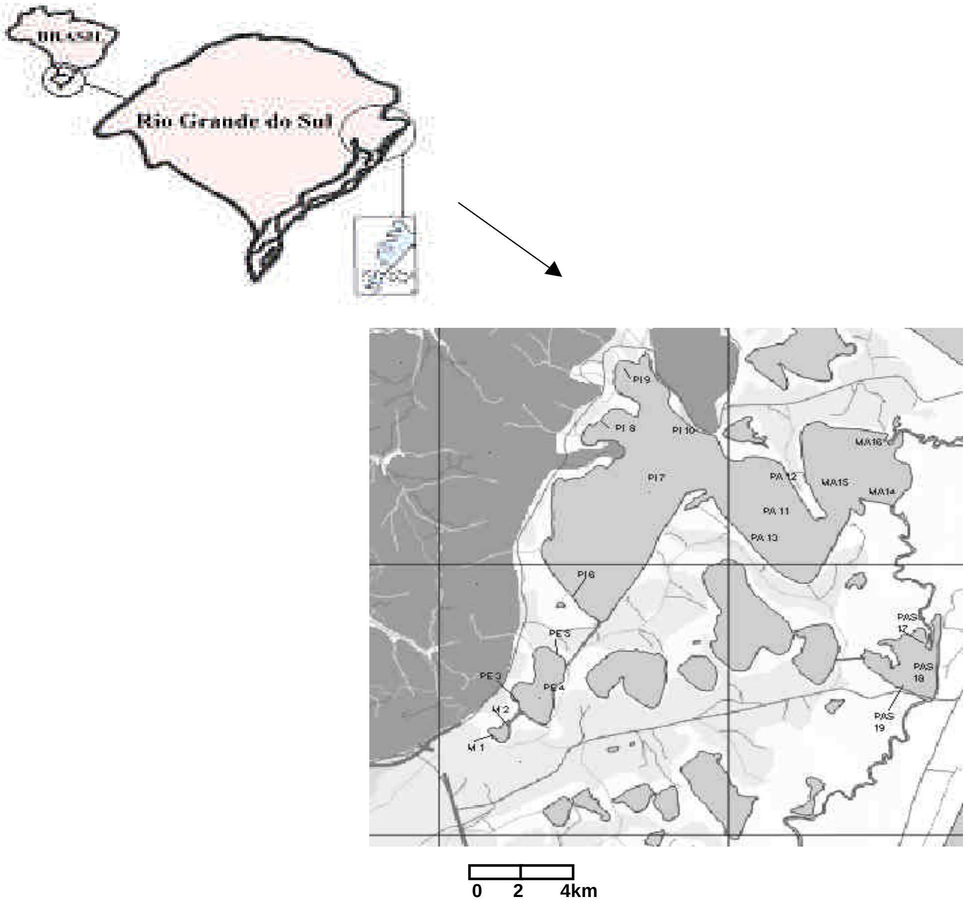

Figure 1: Location of sampling sites. Source: Laboratório de Geoprocessamento, Centro de Ecologia, UFRGS.

Analysis of the definition of the frequency of occurrence of species in the samples was based on the percentages suggested by Dajoz (1973); 0 to 25% - occasional species; › 25 to 50% - accessory species; and › 50% - constant species.

From the abundance data of species with a constant frequency in the system, it was possible to test the hypothesis that zooplankton would exhibit quantitative differences among sampling stations, influenced by the proximity of the contaminated sources, located at Marcelino Lake, a Cluster analysis was performed. The zooplankton quantitative data matrix was transformed by the function log (x + 1). The Horn distance measurement was used to obtain the highest values for the cophenetic correlation coefficients (Horn, 1966).

The grouping method adopted was association by unweighted average (UPGMA) and the cophenetic correlation was obtained using NTSYS computer program (Rohlf, 1993).

Results and Discussion

Zooplanktonic community composition and structure

Sixty-two taxa were identified, as presented in Table II. Rotifera was the richest group with 40 taxa distributed in 19 genera. This pattern is common in tropical freshwaters, whether in lakes, ponds, reservoirs, rivers, or streams according Neves et al. (2003).

Cladocera was represented by 15 taxa (10 genera) and Copepoda by 7 taxa (6 genera). The zooplankton community showed a typical structure, constituted by known species from similar environments in Rio Grande do Sul (RS). This is an opportune time to register the new occurrence of Daphnia gessneri Herbst in this State.

Table II: Composition and frequence of occurrence (%) of zooplankton species in the area of study.

Species	January	May	July	October
Rotifera				
Brachionus angularis Gossé, 1851	78.9	5.2		94.7
Brachionus bidendata Anderson, 1889				5.2
Brachionus caudatus Barrois et Daday, 1894	100.0	15.7	15.7	63.1
Brachionus c. personatus Ahlstrom, 1940	78.9	10.5	5.2	89.4
Brachionus calyciflorus Pallas, 1766	73.6	47.3	5.2	89.4
Brachionus falcatus falcatus Zacharias, 1898	5.3			
Brachionus quadridentata Hermann, 1783	5.3			5.2
Brachionus patulus O. F. Muller, 1786	5.3	5.2		10.5
Euchlanis dilatata Ehrenberg, 1832	68.4	89.4	5.2	5.2
Dipleuchlanis propatula Gossé, 1886				5.2
Filinia longiseta Ehrenberg, 1832	57.8	52.6		15.7
Filinia opoliensis Zacharias, 1898	26.3	63.1		
Keratella cochlearis Gossé, 1886	89.4	84.2	94.7	100.0
Keratella cochlearis tecta Gossé, 1886	15.7	52.6	47.3	21.0
Keratella tropica Apstein, 1907	52.6	10.5	10.5	10.5
Keratella valga Ehrenberg, 1832	42.1	36.8	36.8	78.9
Keratella lenzi Hauer, 1953			10.5	15.7
Keratella americana Carlin, 1943	94.7	89.4	84.2	89.4
Conochilus unicornis Rousselet, 1892	84.2	31.5	10.5	5.2
Hexarthra sp.	63.1	52.6		26.3
Polyarthra sp.	100.0	78.9	89.4	100.0
Platyas quadricornis Ehrenber, 1832	89.4	15.7	5.2	31.5
Ploesoma truncatum Levander, 1894	21.0			5.2
Pompholyx complanata Gossé, 1851	89.4	89.4	89.4	94.7
Lecane bulla Gossé, 1851	36.8	10.5	15.7	42.1
Lecane curvirostris Murray, 1913				5.2
Lecane lunaris Ehrenber, 1832	47.3	15.7	5.2	5.2
Lecane luna Müller, 1776	36.8		10.5	10.5
Lecane leontina Turner, 1892	5.3			5.2
Lepadella sp.	5.3			
Lepadella patella Müller, 1773		10.5		5.2
Testudinella patina Hermann, 1783			5.2	
Ascomorpha sp.		15.7	5.2	
Trichocerca capuccina Wierzejski et Zacharias, 1893	73.6	84.2	15.7	21.0
Trichocerca cylindrica Imhof, 1891	26.3			
Trichocerca similis Wierzejski, 1893	63.2	15.7		
Trichocerca sp.	47.4	84.2	36.8	15.7
Trichotria tectralis Ehrenberg, 1830	26.3			15.7
Scaridium sp.				10.5
Synchaeta sp.	31.5	52.6	26.3	5.2

Table II: Cont.

Cladocera				
Bosminopsis deitersi Richardi, 1895	78.9	57.8	5.2	26.3
Bosmina longirostris O. F. Muller, 1786	100.0	100.0	94.7	100.0
Bosmina hagmani Stingelin, 1904	52.6	73.6	21.0	5.2
Diaphanosoma birgei Korinek, 1981	89.4	63.1	10.5	5.2
Diaphanosoma sp.	36.8	31.5	10.5	
Moina micrura Kurz, 1874	10.5	15.7	5.2	5.2
Moina minuta Hansen, 1899	78.9	36.8		31.5
Ceriodaphnia cornuta rigaudi Richard, 1894	84.2	89.4	5.2	84.2
Ceriodaphnia cornuta cornuta Sars, 1894	78.9	57.8		26.3
Camptocercus australis Sars, 1896	5.3		5.2	5.2
Chydorus sphaericus Baird, 1850	5.3			15.7
Ilyocriptus spinifer Herrick, 1884	5.3			15.7
Daphnia ambigua Scourfield, 1947	42.1	5.2		94.7
Daphnia gessneri Herbst, 1967		5.2		
Leydigia ciliata Gauthier, 1939				10.5
Copepoda				
Acanthocyclops vernalis Fischer, 1853	68.4	94.7	36.8	52.6
Acanthocyclops michaelseni Mrásek, 1901	47.3	42.1	15.7	36.8
Cyclopoida copepodites	100.0	100.0	100.0	100.0
Calanoida copepodites	89.4	89.4	89.4	100.0
Harpacticoida copepodites		10.5	5.2	5.2
Náuplius	100.0	100.0	100.0	100.0
Mesocyclops longisetus Thiébaud, 1914	31.6	15.7	47.3	31.5
Thermocyclops minutus Lowndes, 1934	21.0	84.2	73.7	57.9
Pseudodiaptomus richardii Dahl, 1894		21.0	10.5	5.3
Notodiaptomus incompositus Brian, 1926	73.6	89.4	89.4	100.0
Metacyclops sp.	63.2	78.9	63.1	42.0

It is likely that the climate, as well as other natural characteristics of the system in question, is an influential factor for the composition of the zooplanktonic community. During the year of the study, it was observed a decrease of the number of zooplankton taxa in the period of lowest temperatures, also detected by Bonetto & Ferrato (1966) and Paggi & Jose de Paggi (1990) in the Middle Paraná Basin (Brazil) and by Spohr-Bacchin (1994) and Güntzel (1995) in the Emboaba and Caconde Lakes (RS, Brazil), respectively.

In this study, small organisms like nauplii and rotifers predominated. Even among the cladocerans, small forms, like Bosmina longirostris, Ceriodaphnia cornuta cornuta, and Ceriodaphnia cornuta rigaudi occurred frequently in high densities. An important consideration when there is a predominance of smaller species in lakes, is the possible relation to suspended material in the water column due to the constant influence of the wind. Kirk & Gilbert (1990) documented that the presence of sediments in suspension in natural ecosystems can influence the structure of the zooplankton community by favoring rotifers.

Thus the predominance of Rotifera in this lake system may be related to material in suspension; this aspect was observed with the predominance of Brachionus caudatus and Brachionus angularis, as well as the occurrence of Keratella cochlearis and Polyarthra spp. According to Zurek (1980), cited by Jose de Paggi (1990) several species of rotifers tolerate a high concentration of suspended material because their corona and mastax structures are highly efficient at identifying and selecting the material that will be ingested through the sensorial bristles of the mouth, avoiding inorganic particles.

Rotifers are opportunistic organisms (r-strategist species adapted to a fast population growth during favorable seasons) whose densities change with temperature in a short time (Matsumura-Tundisi et al., 1990).

In the studied lakes, the Cladocera constituted the least significant zooplankton group, represented by Bosmina longirostris, Bosminopsis deitersi, besides Ceriodaphnia cornuta cornuta and Ceriodaphnia cornuta rigaudi.

Environments where microphytoplankton dominate show a great abundance of microconsumers ingesting indirectly bacteria and remains. Arcifa (1984) registered the occurrence of similar species in 10 reservoirs in the state of São Paulo, emphasizing the small proportion of large Cladocera within the zooplanktonic community.

The low diversity of Daphnia seems to be an outstanding feature of cladoceran assemblages in tropical systems, either oligotrophic or eutrophic (Pinto-Coelho et al, (2005).

Kirk & Gilbert (1990) showed that the natural levels of suspended clay (‹ 2 mm) greatly reduced the population growth rates of four cladoceran species, whereas the population growth rates of Brachionus calyciflorus, Keratella cochlearis, Polyarthra vulgaris, and Synchaeta pectinata were not affected by suspended solids. On the other hand, other factors could explain why the Cladocera constituted the least significant group of zooplankton. Besides the presence of solids in suspension, the poor quality of food, in particular the frequent presence of colonial algae like Microcystis aeruginosa and filamentous ones like Anabaena circinalis and Aulacoseira ambigua probably influence the lower richness and density of Cladocera. Sendacz (1993) documented low relative abundances of this group in Jota Lake and Comprida Lake (Brazil), due to the intense bloom of Microcystis aeruginosa and Mougeotia sp.

Jarvis (1986) cited by De Mott (1989) emphasized the decline in the filtering of Daphnia pulex when Microcystis was abundant. Cladocerans were dominant due to high densities of Bosminopsis deitersi during the summer, at Pinguela (PI10) and Palmital (PA12) Lakes, and Bosmina longirostris in autumn, at Marcelino (M1 and M2) and Peixoto (PE3) Lakes. However, Ceriodaphnia was responsible for the peak numbers of Cladocera in the summer at Malvas (MA15 and MA16) and Do Passo (PAS17) lakes.

The feeding pattern of Bosmina, combining passive filtration with active capture of particles, as in the copepods, allows the animal to distinguish between cyanobacteria and other particles (De Mott & Kerfoot, 1982). Thus, this feeding mechanism may explain their preference for large algae over small algae and bacteria, and their densities in Marcelino and Peixoto Lakes.

Copepoda was mainly represented by immature forms of nauplii and copepodites. The feeding habit of the juvenile and immature forms is based essentially on the filtration of small particles. A factor which can determine the proportion of young to adult forms is predation intensity and the balance between predation by invertebrates and vertebrates (Dumont et al., 1994). According to Hutchinson (1967) and Anderson (1970), the cyclopoid copepods are essentially predators, capturing a variety of planktonic organisms, including small Cladocera.

The low number of adults of Copepoda Calanoida may be related to the very low feeding rates on bacteria and picoplankton (Sterner, 1989 cited by Güntzel, 2000) in the more eutrophic lakes (Marcelino and Peixoto), as well as the high concentrations of suspended solids. In addition, there is probably a high rate of predation by invertebrates, since the presence of partially eaten adult Calanoida was noted in most of the samples. Also, according to De Mott (1989), when primary production is low, small species dominate the consumption of available resources and may exclude the bigger species by diminishing the resources to levels that are inadequate for larger species. In the system under study, the primary production, represented by the concentration of chlorophyll a, was high only in the most eutrophic lake, Marcelino, while in the other lakes it was very low, indicating a small supply of food for the larger species (Pedrozo, 2000).

The presence and also the frequency of occurrence of cyanobacteria, for example Microcystis, can inhibit the feeding and even increase the mortality of Copepoda. According to Lampert (1987), even at low densities, copepods avoid to consume this toxic cyanobacteria. In laboratory tests with purified toxins, Dussart & Defaye (1995) confirmed that the sensitivity to these toxins varies among species and also with the ecological characteristics of the biotope.

Table III shows the results of the quantitative analysis of total zooplankton. Variable values were registered, with an overall decrease along the improving environmental gradient, during the four periods of the year. The highest absolute densities of zooplankton were observed at stations M2 and M1 in Marcelino Lake in January, mainly due to Brachionus caudatus, whose total numerical density was 5,066,600 ind.m^{-3} (Tab. IV). These values follow the gradient, decreasing when trophic conditions improve, from to Do Passo Lake, where lower numbers for this species, 1,333 ind.m^3, were detected.

Table III: Total numerical density (ind.m^{-3})of zooplankton species in area of study.

Sampling Sites	January	May	July	October
M1	2806700	1770100	2690	667116
M2	5076900	1513000	41914	2203870
PE3	287304	74752	10759	163779
PE4	322760	91286	27740	68616
PE5	887384	71428	13474	194914
PI6	164792	774930	14964	91509
PI7	68623	96705	3817	17721
PI8	98058	256817	4067	12648
PI9	93005	42798	3435	10063
PI10	139075	61472	3227	14614
PA11	20653	30242	11160	7309
PA12	143296	84228	3130	10324
PA13	32468	108565	33152	4720
MA14	108756	242376	15019	10981
MA15	62053	44729	10052	2779
MA16	128509	113536	7101	9953
PAS17	90494	120571	17314	14176
PAS18	71363	108982	11358	5625
PAS19	66312	96641	16428	3963

The temperature and the availability of food are considered by several authors to be the most important factors controlling abundance of zooplankton in lakes. Even though it is known that it is not only temperature, but a complex of environmental factors, that control zooplankton density, it does have a important role in the reproductive rhythm of zooplanktonic populations.

The northern part of the Coastal Plain of RS, where the studied lakes are located, is under the influence of a humid subtropical climate. The temperature of the water measured during the period of this study ranged between 27.0°C in the summer and 11.3° C in the winter, following the climatic changes of the region. In temperate regions, the seasonal variations of temperature and light can be factors that determine the fluctuating patterns of zooplankton abundance, and this can happen in subtropical regions as well. In sum, the trophic conditions seem to have a strong influence on the seasonality of some species. During the winter, the zooplankton community suffered a decrease in the total density, remaining the Copepoda dominant at all the sampling stations except M2.

In this study the differential contribution of each group changed in time, and the dominant species in Marcelino and Peixoto Lakes tended gradually to lowest percentages in the other lakes.

Rotifera was predominant in January (Fig. 2) at almost all the sampling stations, its relative abundance decreased along the environmental gradient as the quality improved.

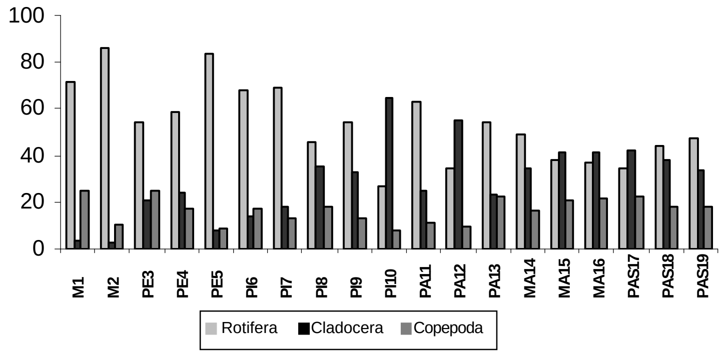

Figure 2: Relative abundance (%) of zooplanktonic representative groups in area of study in January.

In May (Fig. 3), the zooplankton community was characterized by the marked presence of Bosmina longirostris, responsible for the dominance of Cladocera in Marcelino and Peixoto Lakes and high relative abundance. As for the rotifers, the relative abundance of Bosmina longirostris decreased throughout the gradient, allowing the replacement by other species of Cladocera, mainly Ceriodaphnia cornuta cornuta and Ceriodaphnia cornuta rigaudi and larval immatures of Copepoda.

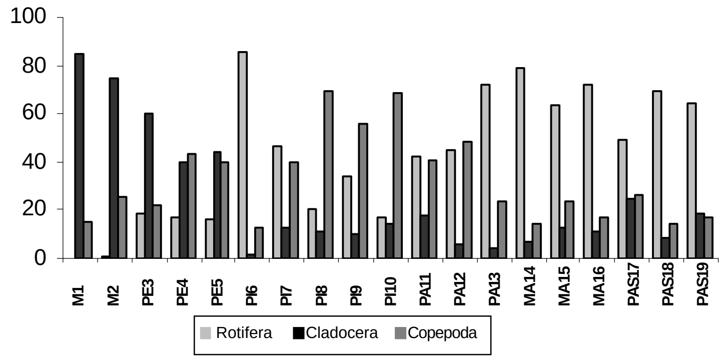

Figure 3: Relative abundance (%) of zooplanktonic representative groups in area of study in May.

During the winter (Fig. 4), represented by the sample taken in July, as already mentioned, it was observed a decrease of the total density of the zooplankton community and the predominance of Copepoda at all sampling stations except M2.

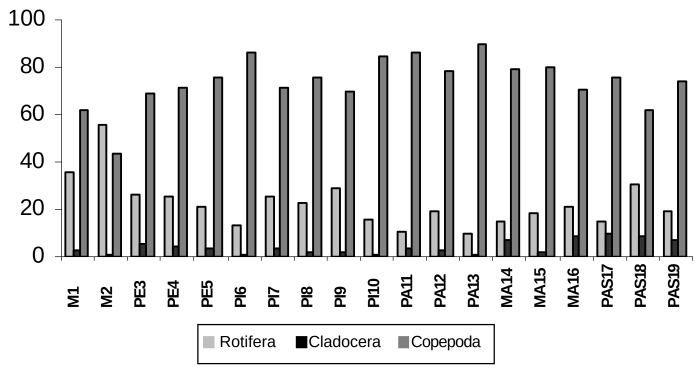

Figure 4: Relative abundance (%) of zooplanktonic representative groups in area of study in July.

This group was represented by larval stages of Copepoda and by the calanoid Notodiaptomus incompositus. The highest densities generally occur in months with the lowest temperatures, because of the inverse relationship between the temperature and reproduction rates in this group.

Changes in the relative importance of the zooplankton groups also occurred in spring, with rotifers dominating in Marcelino Lake and in station PE3 of Peixoto Lake, represented by high relative abundance of Brachionus calyciflorus and Brachionus angularis, and by high densities of larval stages of Copepoda (Fig. 5).

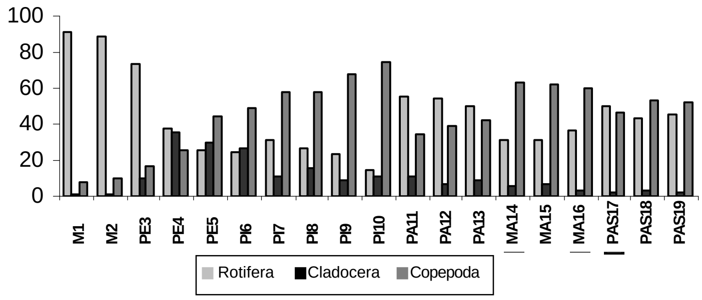

Figure 5: Relative abundance (%) of zooplanktonic representative groups in area of study in October.

This alternation of the zooplankton groups, both spatial and temporal, reflecting the abiotic fluctuations observed in the system, may also reflect possible changes in the phytoplankton composition. In these lakes, the warm months were characterized by high bacterial densities (Pedrozo, 2000) and by the marked presence of filamentous algae such as Anabaena circinalis and Aulacoseira ambigua, among others, while during the autumn and winter months, when the bacterial densities were lower, small algae like Cryptomonas spp. and Nitzchia palea were the most representative of the phytoplankton. A similar pattern was observed in the Oglethorpe Lake by Orcutt & Pace (1984).

Cluster Analysis

The groupings (Figs. 6a, 6b, 7a, 7b) extracted by the cluster analysis reflected the fluctuation in the distribution profile of the zooplanktonic species a long the lakes of the system, confirming the hypothesis that the composition of the biocenosis, as indicated by the zooplankton, reflect the environmental differences between the studied lakes and seasonal changes.

The cluster analysis revealed a spatial differentiation in the four months of the study, and it was possible to show that both species composition and densities were related to the physical, chemical, and biological gradient detected. Not withstanding the small differences between the clusters at different times, it is clear that Peixoto, Pinguela, Palmital, Malvas and Do Passo Lakes were connected by similar high indices, especially in contrast to the distance of Marcelino to the others. Only in October, Marcelino Lake appeared fairly similar to the others, and then it is predictably closest to its spatial neighbour, Peixoto.

Indicators

A more complex interaction with the environmental features of these lakes was found among frequent species. This also may indicate that the lakes can be differentiated effectively not only by physical and chemical factors but also by the distribution of the zooplankton community.

Just as the statistical analysis of the zooplankton data isolate Marcelino Lake from the other lakes, the densities of the frequent zooplankton at the different sampling

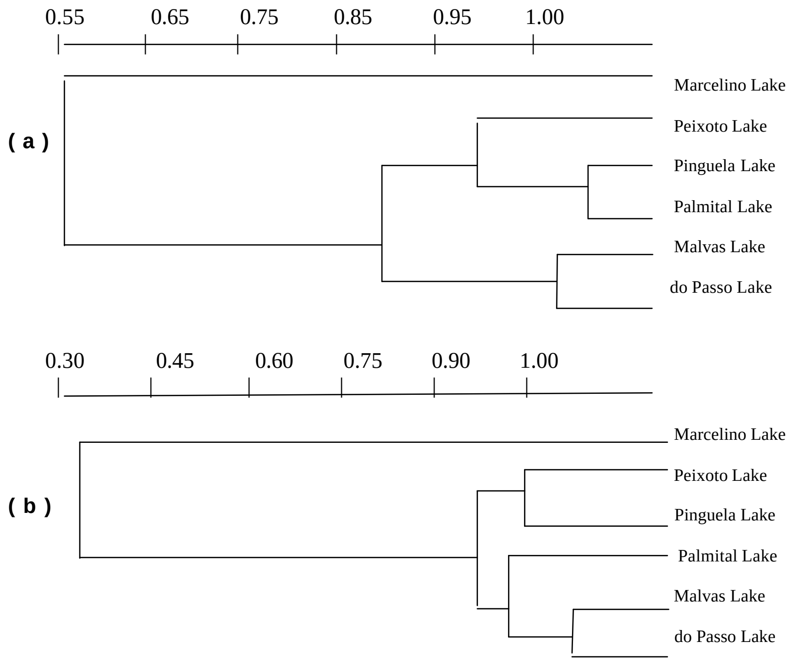

Figure 6: Dendogram of the analysis of similarity clustering (Horn distance) in area of study. January (a), May (b).

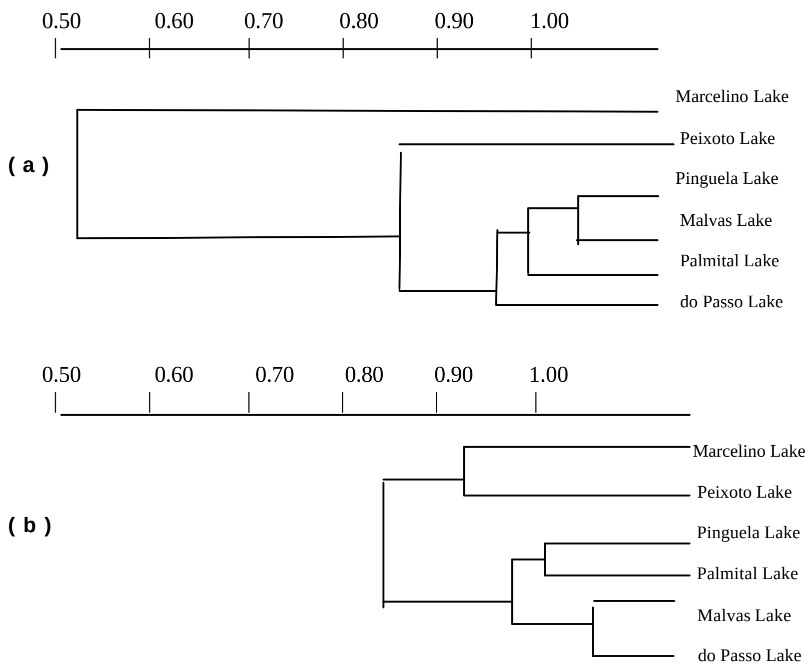

Figure 7: Dendogram of the analysis of similarity clustering (Horn distance) in area of study. July (a) and October (b).

times, as emphasized before, also showed that some species respond quantitatively to the environmental quality gradient of the lakes. Certain species appear benefited by high level of pollution of the Marcelino Lake, mainly in the summer (Tab. IV), like Brachionus caudatus, B. angularis, B. calyciflorus, Polyarthra sp. and Bosmina longirostris. For Ruttner-Kolisko (1974), the genus Brachionus is thermophilic, mainly inhabiting shallow water. Only few species are truly pelagic, and most live near the water sedge, associated to the substratum. All Brachionus feed on algae and partially on bacteria. According to Neumann-Leitão & Souza (1987) B. caudatus is a benthic species, cosmopolitan in eutrophic waters, especially at locations rich in vegetation, occasionally found in the plankton. B. angularis and B. calyciflorus are also cosmopolitan occurring generally in eutrophic waters. Radwan (1980) classifies B. angularis as a summer species that reaches maximum fertility at water temperature of 18°C. From the present data, it can be assumed that besides the importance of the water temperature in the biology of these species of Brachionus, the higher level of organic pollution in Marcelino Lake in the warm months is also an important factor for the presence and abundance of these rotifers, as well the decreasing numbers through the series of lakes of improved environmental quality.

In the summer, at the sampling stations PI10 and PAL12, both located at the edge of Pinguela Lake, the numerical density and consequently the relative abundance of B. caudutus decreased considerably, while the opposite was true of Bosminopsis deitersi, which became dominant. This result suggests that in locations of better environmental quality, B. caudatus (dominant species), together with B. calyciflorus and B. angularis, were replaced by the less tolerant Bosminopsis deitersi and, in general, by a more homogeneous distribution of other species, as shown by their similar relative abundances. According to Montu (1980) Bosminopsis deitersi is a eurithermic species (~16 °C to 29 °C), Bohrer et al. (1988) registered high densities of this species in the Saco de Tapes, a sheltered bay in Patos lagoon, Rio Grande do Sul, in May. Sendacz et al. (1985) recorded Bosminopsis deitersi in great abundance in the oligotrophic reservoirs of São Paulo. Spohr-Bacchin (1994) observed the dominance of this species in the mesooligotrophic Emboaba Lake, throughout the year, except in the winter. In fact, the occurrence and dominance of this species in oligotrophic and mesotrophic conditions is well recorded.

Considering other sampling stations along the gradient, although some species may have been important, none was dominant. Ceriodaphnia cornuta rigaudi was an example of a more homogenous distribution throughout the system. Montú & Goeden (1986) described Ceriodaphnia cornuta rigaudi as eurithermic (13 – 28 °C) and Ceriodaphnia cornuta cornuta as stenothermic thermophilic (26 – 29 °C). In this study Ceriodaphnia cornuta cornuta occurred in all seasons except winter.

Bohrer et al. (1988), relate the dominance of the cornuta form to the presence of planktivorous fish. The occurrence of high densities of the rigaudi form in the studied lakes may probably reflect absence of predation by the fish. Sendacz et al. (1984), related an increase in the relative abundance of these organisms (from 1.9% to 17.7%) to the improved water quality of Billings Reservoir, São Paulo.

Species of the genus Brachionus, among others, were important in the identification of an environmental gradient in the system in the summer while in the autumn, other species exhibited interesting tendencies (Tab. V).

The gradient was also clear in the distribution pattern of Bosmina longirostris in May. The great food availability, due probably to the inflow of nutrients from the sewage discharged in Marcelino Lake, would support the growth of this species which, according to Allan (1976), is opportunistic and, like rotifers, can achieve accelerated growth rates. This species occurs in eutrophic lakes, and Zago (1976) registered its presence at Americana Reservoir as probably indicating eutrophy. More nutrient-enriched lakes or reservoirs support greater crustacean zooplanktonic density and biomass (Pinto-Coelho et al., 2005). B. longirostris was dominant in Marcelino Lake in autumun and winter and at station PE3 in Peixoto Lake in autumn. Together with the rotifers mentioned above, relative abundances of this species

Table IV. Numerical density (indv. m^{-3}) of the constant zooplankton species in the system under study in January 1997.

Taxa	Sampling Sites																	
	M1	M2	PE3	PE4	PE5	PI 6	PI 7	PI 8	PI 9	PI 10	PA11	PA12	PA13	MA14	MA15	MA16	PAS17	PAS18	PAS19
Euchlanis dilatata	0	0	352	48	51	4800	1768	1125	223	92	0	4400	95	642	608	1381	658	1412	1300
Filinia longiseta	0	0	0	0	0	0	156	0	112	0	116	0	189	3208	380	493	165	128	130
F. opoliensis	0	0	881	1296	811	2400	1144	125	409	275	280	450	47	0	0	148	0	0	130
Keratella cochlearis	0	0	2290	4224	1824	100800	11336	31125	3313	2236	4876	5450	17750	17111	3726	7696	0	12833	17810
K. cochlearis tecta	3100	3800	176	48	203	0	0	125	0	0	23	0	0	642	0	345	0	0	910
Keratella americana	0	0	748	624	709	16800	3536	8250	1488	1164	1283	4000	3408	2140	1596	691	1152	1412	1690
Hexarthra sp.	0	0	176	1824	658	0	0	500	0	184	46	50	852	4492	304	2072	329	0	0
Polyarthra sp.	0	0	1585	864	355	520790	13156	0	4206	2389	2100	12500	49510	76358	3726	18598	12344	9625	4420
Pompholyx complanata	0	0	7268	5856	5421	2400	8059	5000	3350	2542	2730	6350	3834	5347	2509	2960	4279	7828	9230
Trichocerca capuccina	0	0	0	48	51	2400	312	375	74	31	210	150	521	3208	228	1184	1811	3721	3510
Trichocerca sp.	0	0	44	48	152	0	208	250	74	92	629	3000	663	44061	9733	26492	26662	24512	11570
Synchaeta sp.	0	0	0	288	253	0	52	0	0	0	0	50	568	6203	0	789	1481	385	1690
Bosminopsis deitersi	0	0	0	0	0	493	67	0	0	243	240	0	892	2457	240	1203	142	306	1283
Bosmina longirostris	1494200	1115400	44200	23180	26933	10237	6075	6930	1866	5110	1440	2533	1297	1492	960	1203	5680	3217	2903
Bosmina hagmani	0	0	0	126	0	0	67	256	233	243	360	506	405	702	240	443	568	153	135
Diaphanosoma birgei	0	0	0	760	800	2096	540	0	116	0	60	253	0	263	0	0	710	230	270
Ceriodaphnia c. rigaudi	0	0	260	10513	3200	1110	4320	16683	1458	2190	2880	1266	1622	7636	4020	6903	8946	11260	12083
Ceriodaphnia c. cornuta	0	0	0	1393	400	0	0	770	0	0	180	760	162	876	0	1456	12922	2298	1350
Acanthocyclops vernalis	89900	35100	520	126	1199	123	203	256	0	243	60	0	0	87	180	127	284	919	338
Thermocyclops minutos	0	0	0	886	1466	246	67	128	758	243	180	506	243	788	60	253	1704	2068	270
Copepodites cyclopoida	117800	175500	1820	5826	6933	11320	4589	21046	3033	4745	1800	5953	2108	9479	2220	6460	9798	8197	8370
Copepodites calanoida	0	0	4680	6206	1466	4070	2295	32083	2858	3772	1140	4686	1378	262	960	633	1420	1072	2025
Náuplii	31000	159900	6500	21913	15200	76960	25717	100100	12133	24698	8400	27360	21170	23875	6300	11083	16330	2221	2835
Notodiaptomus incompositus	0	0	1820	3293	933	740	945	5133	2042	2068	420	2026	486	87	420	127	426	383	1485
Metacyclops sp.	0	0	0	633	533	0	135	1026	992	852	180	253	243	175	360	127	710	230	203

Table V: Numerical density (indv. m^{-3}) of the constant zooplankton species in the system under study in May 1997.

Taxa	Sampling Sites																	
	M1	M2	PE3	PE4	PE5	PI 6	PI 7	PI 8	PI 9	PI 10	PA11	PA12	PA13	MA14	MA15	MA16	PAS17	PAS18	PAS19
Euchlanis dilatata	0	0	352	48	51	4800	1768	1125	223	92	0	4400	95	642	608	1381	658	1412	1300
Filinia longiseta	0	0	0	0	0	0	156	0	112	0	116	0	189	3208	380	493	165	128	130
F. opoliensis	0	0	881	1296	811	2400	1144	125	409	275	280	450	47	0	0	148	0	0	130
Keratella cochlearis	0	0	2290	4224	1824	100800	11336	31125	3313	2236	4876	5450	17750	17111	3726	7696	0	12833	17810
K. cochlearis tecta	3100	3800	176	48	203	0	0	125	0	0	23	0	0	642	0	345	0	0	910
Keratella americana	0	0	748	624	709	16800	3536	8250	1488	1164	1283	4000	3408	2140	1596	691	1152	1412	1690
Hexarthra sp.	0	0	176	1824	658	0	0	500	0	184	46	50	852	4492	304	2072	329	0	0
Polyarthra sp.	0	0	1585	864	355	520790	13156	0	4206	2389	2100	12500	49510	76358	3726	18598	12344	9625	4420
Pompholyx complanata	0	0	7268	5856	5421	2400	8059	5000	3350	2542	2730	6350	3834	5347	2509	2960	4279	7828	9230
Trichocerca capuccina	0	0	0	48	51	2400	312	375	74	31	210	150	521	3208	228	1184	1811	3721	3510
Trichocerca sp.	0	0	44	48	152	0	208	250	74	92	629	3000	663	44061	9733	26492	26662	24512	11570
Synchaeta sp.	0	0	0	288	253	0	52	0	0	0	0	50	568	6203	0	789	1481	385	1690
Bosminopsis deitersi	0	0	0	0	0	493	67	0	0	243	240	0	892	2457	240	1203	142	306	1283
Bosmina longirostris	1494200	1115400	44200	23180	26933	10237	6075	6930	1866	5110	1440	2533	1297	1492	960	1203	5680	3217	2903
Bosmina hagmani	0	0	0	126	0	0	67	256	233	243	360	506	405	702	240	443	568	153	135
Diaphanosoma birgei	0	0	0	760	800	2096	540	0	116	0	60	253	0	263	0	0	710	230	270
Ceriodaphnia c. rigaudi	0	0	260	10513	3200	1110	4320	16683	1458	2190	2880	1266	1622	7636	4020	6903	8946	11260	12083
Ceriodaphnia c. cornuta	0	0	0	1393	400	0	0	770	0	0	180	760	162	876	0	1456	12922	2298	1350
Acanthocyclops vernalis	89900	35100	520	126	1199	123	203	256	0	243	60	0	0	87	180	127	284	919	338
Thermocyclops minutos	0	0	0	886	1466	246	67	128	758	243	180	506	243	788	60	253	1704	2068	270
Copepodito cyclopoida	117800	175500	1820	5826	6933	11320	4589	21046	3033	4745	1800	5953	2108	9479	2220	6460	9798	8197	8370
Copepodito calanoida	0	0	4680	6206	1466	4070	2295	32083	2858	3772	1140	4686	1378	262	960	633	1420	1072	2025
Náuplio	31000	159900	6500	21913	15200	76960	25717	100100	12133	24698	8400	27360	21170	23875	6300	11083	16330	2221	2835
Notodiaptomus incompositus	0	0	1820	3293	933	740	945	5133	2042	2068	420	2026	486	87	420	127	426	383	1485
Metacyclops sp.	0	0	0	633	533	0	135	1026	992	852	180	253	243	175	360	127	710	230	203

decreased along lakes of improving environmental quality. This decrease may be followed by a more homogenous distribution of the percentages among the component species of the zooplankton community, as the water approaches a natural state.

It was possible to observe a reproductive increment in Copepoda, represented by high relative abundances of larval stages, where B. longirostris occurred in low numbers, indicating an improving water quality.

At the beginning of the gradient, with the highest trophic conditions, copepodites of Calanoida were not found from January to July, whereas at other sites along the gradient, these forms were observed. A reproductive increment represented by a rising relative abundance of nauplii and young stage of this group had been already registered in May, being intensified in July. The predominance of these young copepods in winter samples (Tab.VI) reveals their ability to adapt to low temperatures, compared to other groups of zooplankton, and is also related to their feeding by filtering small particles.

Data of Spohr-Bacchin (1994) and Güntzel (1995) also show higher numerical densities in larval forms as well as young Copepods during the colder months, at the Emboaba and Caconde lakes, RS.

The occurrence of Calanoid copepods in Lake Peixoto and beyond could be related to the improved environmental conditions along the system. These organisms were not detected in highly eutrophic reservoirs in São Paulo (Sendacz e Kubo, 1982), but appeared when the environmental conditions showed a sensible improvement. This same tendency may be observed for Ceriodaphnia cornuta cornuta and C. cornuta rigaudi.

During spring (Tab.VII), once again relative abundances of Brachionus species were related to the water quality gradient of the system. Brachionus calyciflorus and Brachionus angularis were represented by the highest densities of the zooplankton in lakes Marcelino and Peixoto, with decreasing values along the gradient.

Daphnia ambigua was abundant in lake Peixoto, following the cyanobacteria bloom that occurred during this period. An association between Daphnia and eutrophic environments has been observed by Hrbacek (1965), Brooks (1969) and Gannon & Stemberger (1978), among others.

Moina minuta was absent only in this lake. Güntzel (2000) observed the replacement of Moina minuta registered in 1979 at the Barra Bonita reservoir by Moina micrura in 1998, emphasizing the value of the latter as an indicator species for eutrophic conditions.

Diaphanosoma birgei represented by high densities in Lake Marcelino in January, decreased along the gradient reflecting that this species is indifferent to the environmental conditions of the system, as others. Zago (1976) observed at the Americana Reservoir a replacement of Daphnia gessneri by Diaphanosoma sp, strengthened by the process of eutrophication. Domingos (1993) also related increased densities of Diaphanosoma birgei in Guarapiranga Reservoir due to the eutrophication of the water body.

Carvalho (1983) considered Ceriodaphnia cornuta a species with a higher capacity than others to adapt to varying abiotic conditions. The relation of this species with the quality of the water of the system showed sensitivity on certain occasions and indifference on others, since the season when the species was frequent and its numerical density was extremely variable along the gradient.

The copepod Acanthocyclops vernalis is considered by Gannon & Stemberger (1978) an indicator of eutrophic environments. Blancher (1984) registered an increase in the abundance of this species related to an increase of the trophic state of the Florida lakes. In the studied lakes, this species showed a similar distribution pattern, with higher numerical densities at poor environmental quality, decreasing to low values in lakes of a better water quality.

The larval stages of Cyclopoida confirmed this tendency, responding to the environmental gradient with changes in numerical density. As their feeding preferences are suited to large quantities of organic and inorganic particles in suspension, their

Table VI: Numerical density (indv. m^{-3}) of the constant zooplankton species in the system under study in July 1997.

Taxa	Sampling Sites																	
	M1	M2	PE3	PE4	PE5	PI 6	PI 7	PI 8	PI 9	PI 10	PA11	PA12	PA13	MA14	MA15	MA16	PAS17	PAS18	PAS19
Keratella cochlearis	400	0	369	995	155	980	32	263	258	256	462	98	811	761	378	672	223	1584	1300
Keratella americana	0	0	344	1137	386	560	440	328	302	106	84	28	0	355	473	84	285	264	130
Polyarthra sp.	200	3400	370	2062	193	140	0	65	0	64	210	69	1216	507	378	252	474	600	130
Pompholyx complanata	0	0	1453	2488	2088	140	440	218	409	21	294	406	203	304	568	420	901	600	17810
Bosmina longirostris	1494200	0	496	1100	492	126	112	79	59	15	256	74	380	769	144	594	1716	850	910
Thermocyclops minutos	0	0	0	0	0	205	20	158	45	45	43	59	253	295	48	66	52	100	1690
Copepodites cyclopoida	440	4954	1926	4015	3442	886	122	136	74	74	555	134	1773	2781	1680	1232	2236	1400	0
Copepodites calanoida	0	0	3208	9350	3867	4152	914	442	327	387	384	193	1266	1420	1008	484	2392	1450	4420
Náupliii	31000	13246	1400	5005	2262	5459	1025	1575	1533	1697	7978	1921	25173	5798	4320	2200	6760	2775	9230
Notodiaptomus incompositus	0	0	816	935	393	2003	538	566	324	476	256	104	380	1065	720	506	1092	975	3510
Metacyclops sp.	0	0	0	0	0	0	0	91	45	29	213	29	253	355	144	154	312	75	11570

Table VII: Numerical density (indv. m^{-3}) of the constant zooplankton species in the system under study in October 1997.

Taxa	Sampling Sites																	
	M1	M2	PE3	PE4	PE5	PI 6	PI 7	PI 8	PI 9	PI10	PA11	PA12	PA13	MA14	MA15	MA16	PAS17	PAS18	PAS19
Brachionus angularis	142600	733650	40083	3093	2200	1050	45	188	74	0	69	36	94	361	66	113	630	208	308
Brachionus caudatus	18600	29200	1850	290	0	0	0	0	0	36	0	0	31	213	10	46	42	64	28
Brachionus calyciflorus	341000	989150	56733	4156	6599	450	45	81	74	36	0	36	15	85	10	46	0	0	28
Keratella cochlearis	86800	175200	14183	9860	27500	7950	1896	1183	589	628	936	586	438	914	193	680	2268	848	602
Keratella valga	3100	0	0	386	1650	300	90	107	0	12	35	36	15	64	10	68	42	64	28
Keratella americana	0	0	1232	2223	4949	1800	316	161	270	242	208	220	94	318	86	861	924	416	280
Polyarthra sp.	3100	10950	616	290	550	1050	181	54	123	12	104	293	109	191	53	317	630	144	70
Pompholyx complanata	12400		3700	5703	5500	3750	2347	1048	1007	857	2531	4326	1473	1084	400	1246	2058	528	154
Bosmina longirostris	9506	27010	14060	5636	41046	5255	472	511	157	157	252	126	246	108	43	143	140	47	29
Ceriodaphnia cornuta rigaudi	0	0	0	2670	2640	3504	566	454	394	433	180	348	51	144	88	32	56	59	29
Daphnia ambigua	413	1460	1356	14833	12906	7804	566	454	236	826	312	237	51	126	58	79	0	12	15
Acanthocyclops vernalis	4546	1460	370	2373	2346	637	94	170	53	0	0	0	0	0	0	0	0	24	0
Thermocyclops minutus	620	0	0	0	0	159	0	56	26	78	0	32	8	54	5	16	28	0	0
Copepodites cyclopoida	13640	71540	4193	4153	7333	4300	1275	1051	1076	1573	468	602	255	1440	356	1235	1507	809	411
Copepodites calanoida	1240	2190	1973	1928	3520	4460	2125	1165	1733	2832	672	1093	586	1818	523	1646	670	536	132
Náuplii	20873	133590	18500	6380	63250	19500	4875	3307	2808	747	1008	1805	892	3042	640	2454	4020	1238	1437
Notodiaptomus incompositus	6820	4380	1973	2522	7333	1911	519	397	420	4287	360	412	195	522	191	617	335	262	58

highest relative abundance at the beginning of the gradient confirm the idea of better adaptation to more eutrophic environments.

Thermocyclops minutus, though occurring in low densities, was frequent in May, July and October. Reid (1989) and Sendacz (1993) related this species to environments with oligo to mesotrophic characteristics. For Reid et al. (1988), this species has a tendency to occur in the less productive waters, or with lower values of electrical conductivity. It was also common in the less eutrophic reservoirs of São Paulo studied by Sendacz & Kubo (1982) and Sendacz et al., (1985). Rocha et al., (1995) associated Thermocyclops minutus with oligotrophic water and Thermocyclops decipiens with more eutrophic water-bodies.

Notodiaptomus incompositus exhibited a variable pattern of occurrence in the system under study. In summer, autumn, and winter, it was found in increasing numerical densities related to improved water quality, but in spring, the density pattern of this species was totally reversed, the highest densities being observed in Marcelino Lake (from which it was completely absent in the other seasons) with a fall-off towards Do Passo Lake. This behavior may imply that this species is basically indifferent to the physicochemical quality of the water at least over this time period. It is also possible that the densities of Notodiaptomus incompositus are more related to the phytoplankton composition in the system than to the abiotic variables themselves, since in spring, high densities of Microcystis aeruginosa and also Aphanocapsa sp. were observed by Padilha (2001).

There are few references about this species, which until now has been recorded only in South America (Argentina, Uruguay, and Brazil). Fallavena (1985) observed in Negra Lake, Rio Grande do Sul, higher densities of this species of Calanoida also in the spring. The water in Negra Lake is dark due to the constant suspension of the sediment by wind, with a large quantity of organic material and acid pH.

Conclusions

The zooplankton community of the lakes of this system was characterized by species already known in similar environments in the same region of Rio Grande do Sul. The climate, the presence of suspended solids, the consequent decreased availability of food, and the progressive water quality gradient towards eutrophication were the main factors governing the composition and structure of the zooplankton community.

The numerical density and species richness of zooplankton were higher in the summer, with a marked depression in the colder months; the climate was one of the main factors controlling population size in this community.

The groups of lakes identified by cluster analysis reveal that diferent species associations occurs among the lakes of the system, confirming the hypothesis that the biocenosis responds to physicochemical changes and that some of these species are good indicators. Brachionus caudatus, Brachionus angularis, Brachionus calyciflorus, Keratella cochlearis tecta, Euchlanis dilatata, Filinia longiseta, Bosmina longirostris, Moina micrura and Acanthocyclops vernalis were considered “tolerant” or “benefited” by the organic contamination in the system. Keratella cochlearis, Keratella americana, Keratella tropica, Keratella valga, Trichocerca capuccina and Pompholyx complanata, Ceriodaphnia cornuta cornuta, Ceriodaphnia cornuta rigaudi, Diaphanosoma birgei and Notodiaptomus incompositus were “indifferent” to the organic contamination. Bosminopsis deitersi, Moina minuta, and Thermocyclops minutus were “sensitive”, being considered indicators of low level of organic pollution.

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